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Grazing pressure by the tammar (*Macropus eugenii* Desm.) on the vegetation of Garden Island, Western Australia, and the potential impact on food reserves of a controlled burning regime

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Abstract

Tammar (*Macropus eugenii* Desm.) populations occur in a restricted number of Western Australia mainland locations and two offshore islands. From faecal pellet epidermal remnants and analysis of stomach contents, eleven plant species were documented as dietary species of the tammar population of Garden Island. Of special preference were the dominant shrub *Acacia rostellifera*, introduced herbaceous species *Asphodelus fistulosus* and *Asparagus asparagoides*, and the native grass *Stipa flavescens*. Grazing damage to these species was generally restricted to localized sites thus assuring their continued survival on the island. Exclosure studies demonstrated a marked impact of grazing on *Asparagus asparagoides*, *Geranium molle* and *Stipa flavescens*. Two small ground herbs, *Parietaria debilis* and *Galium murale* showed increases in cover in areas where larger species were removed by grazing. The tammar was generally attracted to areas of new growth regenerating after disturbance. This suggests that a planned fire management programme incorporating a system of fire breaks, fire protection access routes and low fuel buffers should meet the perceived objectives of protecting the naval installations, maintenance of the food resource and hence, continued survival of the tammar populations on the island. The remaining areas of long-unburnt vegetation should be retained to provide cover for the tammars and to conserve the native vegetation of the island, especially fire sensitive species.

Introduction

The tammar (*Macropus eugenii* Desm.) is a herbivore from the family Macropodidae. Its present range in Western Australia is restricted and includes only Garden Island, West Wallabi Island, and a few isolated pockets on the mainland in the south-west. In the early 1970s the number of tammars on Garden Island was estimated at 2 000 (Bakker 1973) where as current sampling suggests the population is around 1700 (A. Bradley, pers. comm.). This small wallaby is also found in South Australia and more particularly on Kangaroo Island (Kelsall 1965). Its distribution patterns in south-west Australia have been associated with a range of site factors, but of special importance are dense thickets of vegetation which provide protection from predators and associated grass species thought to be a preferred food resource (Christensen 1981).

Other studies on the tammar have concentrated on physiological factors (Kelsall 1965, Kinnear *et al.* 1968, Bakker *et al.* 1982). Any reference to the dietary habits of the tammar in these studies was based on observation of grazing damage and extrapolations from other marsupial studies. Christensen (1981) studied the biology of the tammar in relation to fire and listed several major characteristics which might contribute to the adaptation of the tammar to a fire-prone habitat. These include: (1) seasonal breeding, (2) lack of repression of juveniles, (3) group territoriality, (4) wide dispersal, (5) absence of panic during fire, and (6) some fidelity to home range. It is, however, the direct effects of fire on the plant communities of Garden Island which will ultimately affect this population since fire protection is an important requirement of the recently established naval facilities on this island.

Currently the W.A. Bushfires Board, W.A. Department of Conservation and Land Management, the Department of Defence (Navy) and the University of Western Australia Departments of Zoology and Botany are cooperating in a research effort to understand the ecology of the tammar and to develop an appropriate fire management plan that will both protect life and property and ensure the short- and long-term health and survival of this endangered species. The objective of this study was to determine the plant species important in the tammar diet and to make preliminary comments on the potential impact that a fire management plan might have on the population.

Methods

Garden Island (115°40'E, 32°16'S) is a near-shore island centred approximately 35 km southwest of Perth and southward of Rottnest and Carnac Islands. It measures 9.5 km from north to south and 2 km at its widest point. The islands are estimated to have been separated from the Western Australian mainland for 6 000-7 000 (Main 1961). The major plant formations are dense stands of shrub scrub dominated by *Acacia rostellifera* and low forests dominated by *Callitris preissii* and *Melaleuca lanceolata*. For a more detailed

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discussion of the major landforms and the vegetation associations of the island, refer to McArthur and Bartle (1981).

Exclosure studies

Four tammar grazing exclosures measuring 10 x 25 m with 1.5 m high fences of 2 cm wire mesh were established in a range of plant communities and regions of Garden Island in May 1983 (Fig. 1). Selection of the exclosure sites was based on evidence of local grazing by tammars, time since the last fire, and proximity to the Zoology Department's population sampling sites. The Beacon Head Site, on the most northern portion of the island, was situated in an area classified as *Acacia rostellifera* Open Scrub; the Cliff Point Site near the central western coastline in an area of *Melaleuca lanceolata* Open Heath; the Denham Road Site in the centre of the southern half of the island in *Melaleuca lanceolata—Acacia rostellifera* Low Open Forest, and the Quarry Road Site near the southeastern tip of the island in *Melaleuca lanceolata* Open Scrub. The Beacon Head Site was burnt in December 1982. The Cliff Point and Denham Road Sites probably last burned in the disasterous fire of January 1956 which burned most of the island north of Careening Bay (Baird 1958). The Quarry Road Site lies in a region which has probably remained fire-free for more than 40 years.

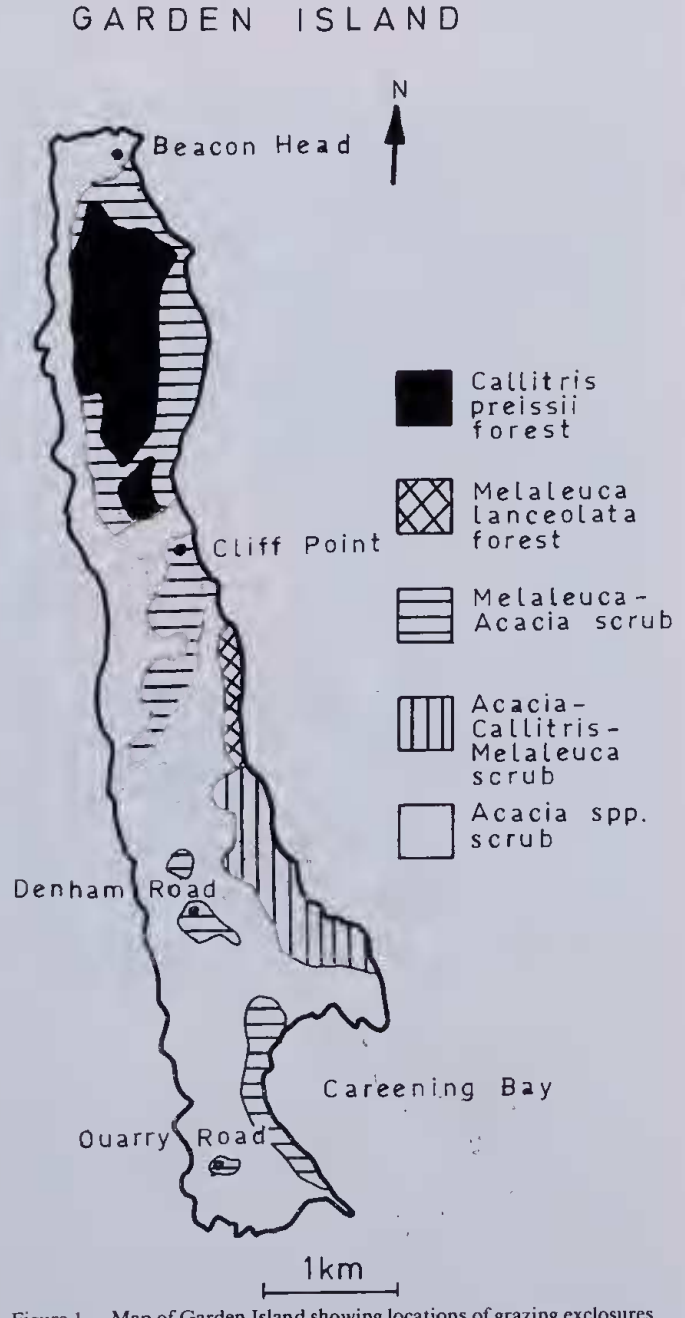

Figure 1.—Map of Garden Island showing locations of grazing exclosures (●) and major vegetation types (modified from McArthur and Bartle 1981).

Percentage cover values for all vascular species were visually estimated from permanently marked transects of ten 1 m^2 quadrats. One transect was situated inside and one immediately adjacent but outside the exclosure at each site. Cover values for selected species were estimated in August 1983 and a full survey of all species was made in September 1985. From these estimates mean percentage cover values for species in each transect were determined.

Tammar diet studies

The dietary preferences of the tammar were determined by analysing the epidermal remnants from faecal pellets and from the stomach contents of two road-killed animals. A total of 40 faecal pellets were collected; 5 from outside each of the tammar grazing exclosure areas and 20 from a range of habitats generally distant from the Naval installations. The emphasis on native areas was made to reduce likely grazing by tammars of the irrigated lawns and domestic gardens within the settlement area which is known to occur (McArthur and Bartle 1981). One series of samples was obtained prior to the onset of winter rains (April, 1983) and a second in late winter (August, 1983). The road-killed animals were obtained during April 1983 from an area just north of the North Gate of the Naval installation. The stomach contents were removed immediatcly upon collection and frozen for later analysis.

The identification of epidermi in the faecal pellet and stomach content materials followed the methods of Halford *et al.* (1984a) which were modified from the original techniques reported by Storr (1961) and Jain (1976). Comparisons of faecal pellet epidermal remnants to epidermal samples prepared from plant tissue provided information on tammar diet preferences. Frequencies of the proportions of the epidermal fragments from microscopic analysis provided an estimate of dietary preference (Halford *et al.* 1984b).

Direct grazing observation and re-establishment response

Plants throughout the island were checked for direct signs of grazing and, where tammars could be observed grazing or browsing particular shrubs, these species were recorded. Plant species were also categorized for re-establishment strategy. Disturbance to a plant community can result from fire damage, animal grazing or the mechanical removal of vegetation such as occurs in firebreaks or alongside roads. Post-fire modes of re-establishment have been widely documented (Specht *et al.* 1958, Keeley and Zedler 1978, Keeley and Keeley 1981, Malanson and O'Leary 1982, Bell *et al.* 1984). In contrast there is a paucity of information concerning re-establishment strategies following grazing damage and mechanical disturbance. In relation to fire, species can be described as ephemerals, obligate seeders and sprouters (Bell *et al.* 1984), although re-establishment strategies may vary within a particular species as well as

between species. Mode of re-establishment may also vary depending upon the intensity of the fire or the degree of damage sustained from non-pyric disturbances. In the main, fire prone environments are high in the proportion of resprouting species (Siddiqi *et al.* 1976, Bell *et al.* 1984). Similarly, areas subjected to repeated mechanical disturbance might favour resprouters, although obligate seeders with a bradysporous habit may also survive clearing operations (Griffin and Hopkins 1981). Similar information is not available for grazed plants, but it might be assumed that resprouting species would, in the long term, have a greater chance of survival than obligate seeding species. The collection of re-establishment data allowed the prediction of changes which might occur following an imposed controlled-burning regime.

Results

Exclosure studies

Twenty-nine species of vascular plants were identified in and adjacent to the four tammar exclosure study sites (Table 1). Only *Acanthocarpus preissii* and *Phyllanthus calycinus* occurred in every transect and only eight species occurred in more than half of the study transects. Of these common species, those showing major differences between the inside and the outside of the exclosures were *Acanthocarpus preissii, Asparagus asparagoides, Geranium molle* and *Stipa flavescens*, which were much more common inside, and *Galium murale, Parietaria debilis* and *Phyllanthus calycinus*, which showed consistently higher cover values outside the grazing exclosures. The most obvious effect of the grazing exclosure occurred at the recently burned Beacon Head site where *Asparagus asparagoides* averaged 78.9% under protection and only 1.8% where exposed to grazing.

Comparisons of mean cover values of the common species after about four months grazing protection (1983) and after more than two years protection (1985) showed an increase in the difference between protected and unprotected samples for those species with greater cover inside the exposures (Fig. 2).

Faecal and stomach content studies

Eleven different species of vascular plants were identified in the tammar faecal pellet material and stomach contents (Fig. 3). The most common were *Asphodelus fistulosus, Acacia rostellifera* and *Asparagus asparagoides*. The August faecal pellet samples included a greater variety of species (11 species) compared to either the April faecal pellet sample (5 species) or the April stomach contents sample (8 species).

Re-establishment following grazing or fire

Direct observations of tammar grazing proved difficult although seven plant species were confirmed as dietary species. These seven species, however, had already been identified from faecal pellets or stomach content analyses. Of significance was that the tammars seemed to prefer young shoots of the resprouting species or seedlings.

Of the forty-seven species identified from the 1983 and 1985 samplings, only ten are known to re-establish from existing rootstocks following intense fires with the remainder either ephemerals (16 species) or obligate seeders (20 species) (Table 2). Of this total sample, 26% (12 species) were introduced, and, of the eleven dietary species, 27% (3 species) were introduced.

Table 1.

Mean percentage cover values for transects inside and outside the Garden Island Tammar exclosure study sites for data measured September 1985.

Species	Beacon Head		Cliff Point		Denham Road		Quarry Road	
	In	Out	In	Out	In	Out	In	Out
Acacia rostellifera	—	3.1	0.1	0.3	2.0	43.7	—	—
Acanthocarpus preissii	5.8	1.9	12.5	7.4	24.0	13.7	86.0	62.4
Anagallis spp.*	5.2	1.4	—	1.7	1.1	—	—	0.1
Asparagus asparagoides	78.9	1.8	12.7	0.2	—	0.2	—	—
Asphodelus fistulosus	—	1.4	1.3	10.1	—	0.8	—	—
Carduus pycnocephalus	—	1.1	—	—	—	—	—	—
Clematis microphylla	—	—	2.7	—	—	—	36.1	0.1
Crassula colorata	—	—	7.3	0.4	—	—	—	—
Daucus glochidiatus	—	0.1	—	—	—	—	—	0.1
Eremophila glabra	0.7	22.4	—	—	—	—	—	0.4
Galium murale	4.6	48.8	6.8	28.2	—	0.2	—	—
Geranium molle	—	0.4	23.7	0.1	16.1	—	1.0	0.8
Guichenotia ledifolia	—	—	1.9	—	—	—	—	—
Hardenbergia comptoniana	—	—	—	—	—	—	6.9	—
Leucopogon insularis	—	—	9.5	—	—	—	8.1	—
Leucopogon parviflorus	—	—	—	—	—	—	0.1	2.1
Oxalis pes-caprae	—	—	—	—	—	—	0.1	—
Poranthera microphylla	—	0.1	—	—	—	—	—	0.1
Parietaria debilis	—	0.1	—	—	6.2	56.1	3.4	4.2
Phyllanthus calycinus	0.5	6.5	0.9	8.8	0.4	1.1	0.2	7.8
Rhagodia baccata	—	—	—	—	—	—	0.4	—
Senecio lautus	—	—	—	—	0.3	—	0.4	—
Solanum symonii	—	0.7	—	—	—	—	—	—
Sonchus oleraceus	3.6	0.2	0.5	—	—	—	0.3	—
Spyridium globulosum	—	—	—	—	0.1	—	0.5	—
Stipa flavescens	—	—	10.2	0.1	5.8	0.1	—	1.0
Thomasia cognata	—	—	0.2	—	—	—	—	—
Trachyandra divaricata	—	—	—	0.5	—	—	—	1.3
Zantedeschia aethiopica	—	—	—	—	2.6	0.2	3.2	0.6

*Includes both *Anagallis arvensis* and *A. foemina*

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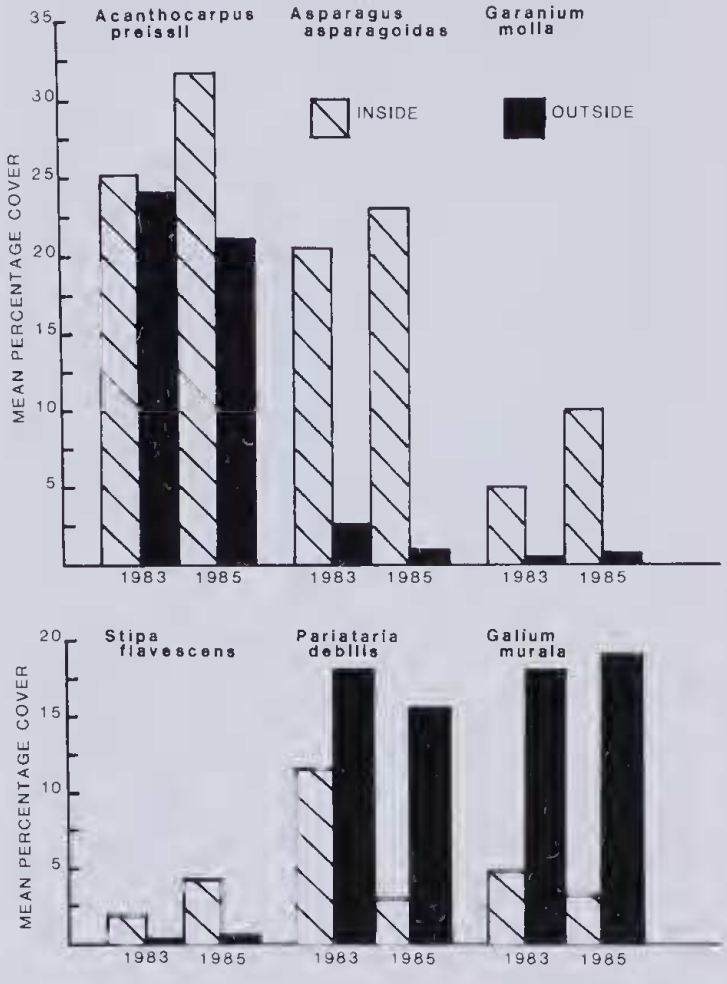

Figure 2.—Mean percentage cover values from the four exclosure sites for selected species sampled inside and outside the exclosure during August 1983 and September 1985.

Discussion

The tammar wallabies on Garden Island appear to be versatile feeders. Preferred plants generally included young shoots from resprouting species (*Stipa flavescens*, *Asparagus asparagoides*), seedlings (*Solanum symonii*, *Thomasia cognata*) or short-lived ephemeral species (*Asphodelus fistulosus*). Results obtained from the examination of faecal and stomach material indicated that the introduced ephemeral, *Asphodelus fistulosus*, dominated the diet of the tammar. This species is now particularly widespread over the island, although differences in cover values were not particularly apparent in the exclosure studies due to a tendency of this species to be concentrated in disturbed areas such as along road verges and in fire breaks. At the Cliff Head site in the grazed area surrounding the exclosure, many individuals appeared to have invaded the area following an initial period of grazing. Grazing observations suggested that the tammar preferred areas where recent mowing or ploughing stimulated the production of new shoots or seedlings.

The presence of *Acacia rostellifera* in both faecal and stomach material indicated a strong preference for this species. Other authors have reported various species of *Acacia* in the diet of the tammar and other Macropods (Storr 1961, Kelsall 1965, Christensen 1981, Halford *et al.* 1984b). Probably because of the high density and widespread distribution of *Acacia rostellifera* on Garden Island, direct grazing evidence was not apparent. Kelsall (1965) noted that the tammar preferentially grazed this species in the dry season. In this study no seasonal preference for *Acacia rostellifera* occurred between the late Autumn first sampling period and the late Winter second sampling when water would be readily available. During summer the thick central parenchymatous tissue of the phyllods of this species could be an important source of moisture. Preference for legume species could also relate to greater foliar nitrogen levels (Halford *et al.* 1984b).

Previous research established that grasses were a dietary preference in mainland populations of the tammar (Christensen 1981). *Stipa flavescens* has a relatively wide but discontinuous distribution over Garden Island occurring in higher densities in scrub communities where *Acanthocarpus preissii* was either absent or present in low densities. In these regions *Stipa flavescens* tussocks often showed evidence of grazing damage. The limited evidence for this species in the faecal and stomach content analyses, however, could be mainly an artifact of the laboratory technique. The nitric/chromic acid maceration technique entirely digests the epidermi of grasses and the digestion processes of the tammar could duplicate this process. Cautionary procedures regarding grass epidermal remnants have been pointed out previously (Storr 1961, Halford 1984a).

The Beacon Head exclosure site located in a small experimental burn area showed vigorous regrowth of *Asparagus asparagoides*. The major cover differences between areas inside and outside the fences and the common occurrence of this plant species in both the faecal and stomach content samples implicate *Asparagus asparagoides* as a favoured dietary component. Evidence of near complete digestion of epidermi of young leaves

Figure 3.—Proportions of fragments separated by species from the April and August, 1983 faecal pellet samples and the April, 1983 stomach content samples.

of this species in the preparation of the voucher slides suggests that fragments noted from the faecal pellet and stomach content analyses probably underestimate the actual proportions ingested.

Grazing damage to *Rhagodia baccata* on Garden Island has been previously documented (McArthur 1957, Kelsall 1965, McArthur and Bartle 1981). The absence of this species in the dietary preferences noted in this study, however, is probably due to the particular location of the exclosure sites in respect to the occurrence of *Rhagodia baccata*. Other inconsistencies arising between the direct observation of grazing pressure and the quantitative evidence may also be explained by the distribution and density patterns of individual species and/or relatively low number of pellets analysed. For example, *Callitris preissii*, which did not occur in the transects, was identified from the stomach contents of the road-killed animals.

In the twelve years since completion of the new naval facilities the tammar population has remained relatively constant; the difference of 300 animals between the pre-1973 and current estimates could be attributed to the general difficulty of accurately sampling animal populations. Given the feeding preference for young shoots and seedlings, combined with the known behaviour of the tammar during fires (Christensen 1981), a controlled burning regime on Garden Island could benefit the population of this rare marsupial by increasing the areas of regenerating vegetation. However, the large proportion of species requiring seedling re-establishment indicates that the vegetation of Garden Island does not normally have a regime of frequent natural burns and, therefore, it would be irresponsible to suggest that large areas of the native vegetation be burned to provide greater feeding areas for the tammar. In fact, the greater availability of preferred food following large area burns could result in unacceptably large population increases in the tammar population. Frequent fires could also increase the already considerable invasions of introduced species into the native plant communities of the island as has been noted elsewhere in small 'island-like' bushland reserves within metropolitan Perth (Baird 1977, Loneragan *et al.* 1984, Wycherley 1984). The present proportion of introduced species on the island (26%) is similar to that included in the Star Swamp Bushland Reserve (25%) (Bell *et al.* 1979) even though the mainland reserve includes a greater diversity of habitats, communities and species. What could prove beneficial to both the tammars and the human population on Garden Island would be a series of control burns to

Table 2.

Characteristics of Garden Island vascular plants relating to grazing, re-establishment strategy, tammar diet, and floral affiliation.

	Observed grazing damage	Re-establishment strategy	Faecal pellet	Stomach content	Floral affiliation
Acacia cochlearis	—	Resprouter	—	—	Native
Acacia rostellifera	Yes	Resprouter	Yes	Yes	Native
Acanthocarpus preissii	—	Resprouter	—	—	Native
Anagallis arvensis	—	Ephemeral	—	—	Introduced
Anagallis foemina	—	Ephemeral	—	—	Introduced
Asparagus asparagoides	Yes	Resprouter	Yes	Yes	Introduced
Asphodelus fistulosus	Yes	Seeder	Yes	Yes	Introduced
Beyeria viscosa	—	Seeder	—	—	Native
Boronia alata	—	Seeder	—	—	Native
Callitris preissii	—	Seeder	Yes	Yes	Native
Carduus pycnocephalus	—	Ephemeral	—	—	Introduced
Carpobrotus aequilaterus	—	Seeder	—	—	Native
Centaurium erythraea	—	Ephemeral	—	—	Introduced
Clematis microphylla	—	Resprouter	—	—	Native
Crassula colorata	—	Ephemeral	—	—	Native
Crassula pedicellosa	—	Ephemeral	—	—	Native
Diploleana dampiera	—	Seeder	—	—	Native
Daucus glochidiatus	—	Ephemeral	—	—	Native
Eremophila glabra	—	Seeder	Yes	Yes	Native
Exocarpus sparteus	—	Resprouter	—	—	Native
Galium murale	—	Ephemeral	—	—	Introduced
Geranium molle	—	Ephemeral	—	—	Introduced
Guichenotia ledifolia	—	Seeder	—	—	Native
Hardenbergia comptoniana	—	Resprouter	—	—	Native
Melaleuca huegelii	—	Seeder	—	—	Native
Melaleuca lanceolata	—	Seeder	—	—	Native
Lasiopetalum oppositifolium	—	Seeder	Yes	—	Native
Leucopogon insularis	—	Seeder	—	—	Native
Leucopogon parviflorus	—	Seeder	—	—	Native
Olearia axillaris	—	Seeder	—	—	Native
Oxalis pes-caprae	—	Ephemeral	—	—	Introduced
Parietaria debilis	—	Ephemeral	—	—	Native
Poranthera microphylla	—	Seeder	—	—	Native
Phyllanthus calycinus	Yes	Resprouter	Yes	Yes	Native
Rhagodia baccata	—	Seeder	—	—	Native
Scaevola crassifolia	—	Seeder	—	—	Native
Scirpus nodosus	—	Resprouter	—	—	Native
Senecio lautus	—	Ephemeral	—	—	Native
Solanum symonii	Yes	Seeder	Yes	Yes	Native
Sonchus oleraceus	—	Ephemeral	—	—	Introduced
Spyridium globulosum	—	Seeder	—	—	Native
Stipa flavescens	Yes	Resprouter	Yes	—	Native
Thomasia cognata	Yes	Seeder	Yes	—	Native
Trachyandra divaricata	—	Seeder	Yes	Yes	Introduced
Trachymene caerulea	—	Ephemeral	—	—	Native
Trachymene pilosa	—	Ephemeral	—	—	Native
Zantedeschia aethiopica	—	Ephemeral	—	—	Introduced

create low flammable fuel regions around the Naval facilities and to break up the length of the island into units to prevent large areas burning as occurred during the summer of 1956 (Baird 1958).

Garden Island has been largely free of wild fires during the history of European settlement on the mainland. Indications from growth ring analyses from a small stand of *Callitris preissii* located in the northern end of the island which escaped the fire of 1956 showed that the trees were not much older than 50 years (Pearman 1971). This stand would now be around 65 years old. Although growth is generally slow, fuel build up during fire free periods can be considerable. McArthur (1957) reported that after 18 years of accumulation litter depths were of the order of 5 cm in the *Callitris* Forest, 3 cm in *Acacia rostellifera*-Mixed Scrub, and 1 cm in *Melaleuca heugelii* Scrub. His description of the vegetation at the time 4yr prior to the 1956 fire also indicated that *Stipa flavescens* occurred in most of the plant communities and would have contributed to the flammability of the litter.

Small spot fires accidentally lit by island visitors have occurred since the 1956 fire but documentation of these fires is unavailable. Controlled burning trials carried out by the W.A. Bush Fires Board in conjunction with the Department of Botany in April 1982 and December 1982 in the Beacon Head region were the first documented fires for 27 years. Estimates following these small experimental control burns indicated that only about 50% of the lit area actually burnt, and indeed, on both occasions some difficulty was experienced in keeping the fires alight. These controlled burns were carried out under mild temperatures and in the absence of strong winds; in marked contrast to the conditions under which the 1956 fire burned when temperatures in the two weeks preceeding the wild fire averaged 38°C and strong south-westerly winds had prevailed.

The ability to impose a controlled burning regime in a region which normally only rarely receives a fire should not be the only management decision for the regions of native vegetation on Garden Island. As was noted by Krinitskii (1974), 'Man's help should be thoroughly worked out; he should not lightly and arrogantly recarve nature'. The protection of the Naval installations from wild fires could be achieved by a system of fire breaks and reduced fuel-load buffers, rather than the burning of large tracts of the native plant communities of the island which has the additional disadvantage of destroying most of the cover for the tammars. If the fire-breaks were of a firm-base construction (e.g. limestone) rather than ploughed annually, there would be minimal disturbance and, hence, greater probability of controlling weed invasion. Changes in the tammar population numbers that result from the increased areas of preferred food resources could then indicate further considerations for the management of the island.

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